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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 50.

B. T. GALLOWAY, *Chief of Bureau.*

WILD RICE:

ITS USES AND PROPAGATION.

BY

EDGAR BROWN,
Botanist in Charge of Seed Laboratory,

AND

CARL S. SCOFIELD,
Botanist in Charge of Grain Grade Investigations.

BOTANICAL INVESTIGATIONS AND EXPERIMENTS.

Issued August 28, 1903.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

The Bureau of Plant Industry, which was organized July 1, 1901, includes Vegetable Pathological and Physiological Investigations, Botanical Investigations and Experiments, Grass and Forage Plant Investigations, Pomological Investigations, and Experimental Gardens and Grounds, all of which were formerly separate Divisions, and also Seed and Plant Introduction and Distribution, the Arlington Experimental Farm, Tea Culture Investigations, and Domestic Sugar Investigations.

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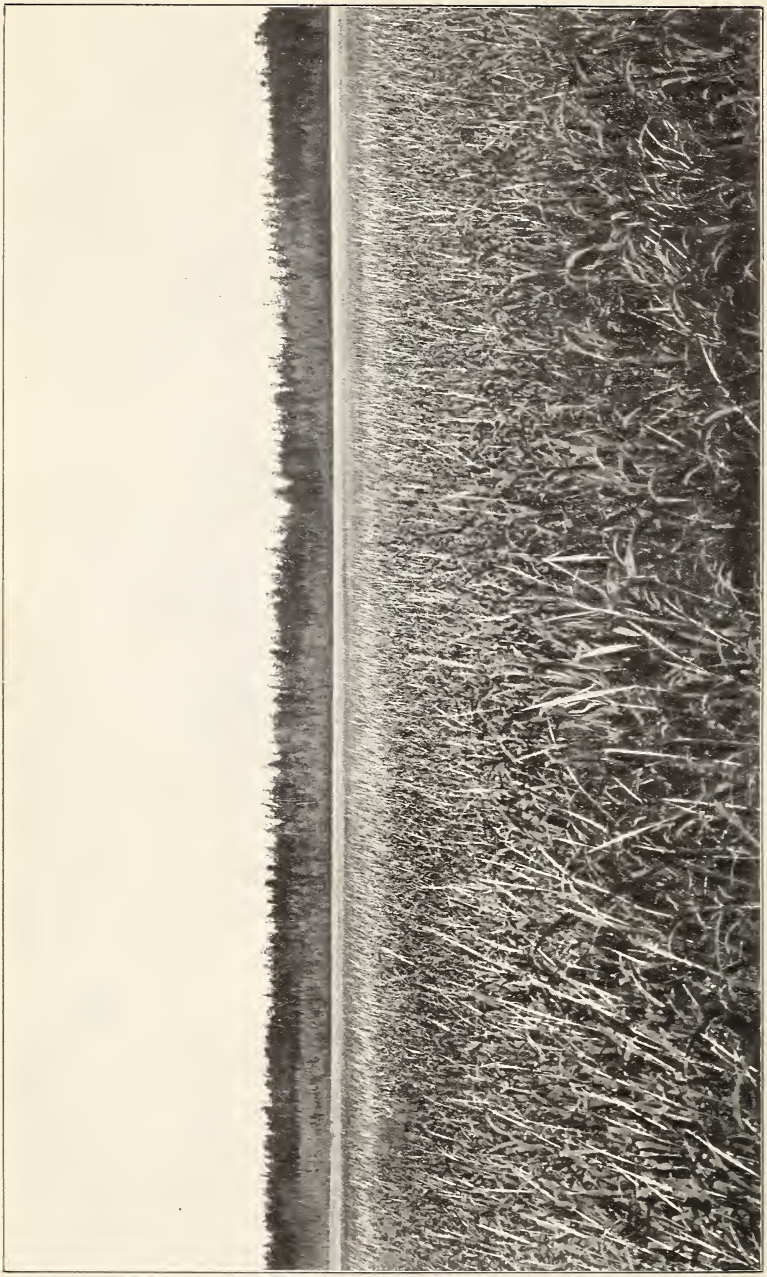

FIELD OF WILD RICE JUST HEADING OUT, NEAR BEMIDJI, MINN.

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BUREAU OF PLANT INDUSTRY.

B. T. Galloway, *Chief of Bureau.*

BOTANICAL INVESTIGATIONS AND EXPERIMENTS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 9, 1903.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 50 of the series of this Bureau, the accompanying paper entitled "Wild Rice: Its Uses and Propagation."

This paper was prepared by Mr. Edgar Brown, Botanist in Charge of the Seed Laboratory, and Mr. Carl S. Scofield, Botanist in Charge of Grain Grade Investigations, and has been submitted by the Botanist with a view to publication.

The seven half-tone plates are essential for the purposes of this bulletin.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

Wild rice (*Zizania aquatica*) is still an important, if not the chief, farinaceous food for probably 30,000 of the American aborigines, notably the Ojibwas. It is the principal fattening agent too for myriads of wild fowl in the eastern half of the United States. It is now being placed on the market in a small way as a breakfast food. On account of its great value as a food for game birds it has been widely and justly recommended as a suitable plant for shallow lakes and sluggish streams which are maintained as shooting preserves. The seed has been extensively marketed, but in most cases with results unsatisfactory to the buyer, for usually it fails to germinate. So nearly universal was the difficulty that some seedsmen who did not wish to disappoint their customers refused to handle the seed, or sold it only in small quantities. For a time it was supposed that the loss of vitality was due to the scorching to which the seed was subjected when gathered for food by the Indians, but it was found that seeds which had never been scorched failed also to germinate. It was then determined to try a series of experiments based on the observation that the grain of wild rice is still somewhat soft and moist at maturity and falls into the water immediately without hardening. These experiments, which are recorded in this report, show that the way to preserve the vitality of the seed is to keep it from becoming thoroughly dry, at the same time aerating it sufficiently to prevent molding. The practical course suggested to buyers is to place their orders before the time of the wild rice harvest, have the seed shipped immediately on maturity, and sow it at once.

The observations and experiments were delegated to two investigators, Mr. Carl S. Scofield, who made an examination of the plant in its natural situation in Minnesota, and Mr. Edgar Brown, who conducted the storage and germination tests.

FREDERICK V. COVILLE,
Botanist.

OFFICE OF THE BOTANIST,
Washington, D. C., July 3, 1903.

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WILD RICE: ITS USES AND PROPAGATION.

INTRODUCTION.

The importance of wild rice as a food for wild fowl and the interest in its artificial propagation are indicated by the large number of inquiries regarding it that have come to the Department of Agriculture during recent years. These inquiries have emanated from many different localities widely separated, thus showing that the interest in this plant is not confined to any limited region. The general demand has been to know where viable seed of this plant could be obtained and how and where it should be sown to bring successful results. Some interest has also been manifested in the possibilities of preparing from this seed a commercial cereal food.

The seed of wild rice has been used for food by the Indians, particularly those of the middle Northwest, since as long ago, at least, as the first acquaintance of the white man with their customs. Notwithstanding the abundance of other forms of cereal food, such as flour and corn meal, since the advent of the white man, the Indian of the upper Mississippi Valley has continued to use large quantities of wild rice, and this too in spite of the fact that the harvesting and curing of the seed require considerable arduous labor. Wild rice, as prepared for food by the Indians, is highly esteemed by the white men who have had the opportunity of testing it and the entire available supply now sells at from two to three times the price of ordinary white rice.

While by far the largest demand for information regarding this plant has come from men or organizations wishing to secure viable seed for planting near shooting grounds to attract wild fowl, the possibility of preparing from the seed a large and regular supply of a nutritious and highly flavored cereal food has received some attention. The importance of maintaining good feeding grounds for wild fowl, of which the propagation of wild rice is a very important element, needs no discussion, and the desirability of propagating a plant which will make the otherwise waste-water areas of the upper Mississippi Valley yield a valuable and highly esteemed cereal is also evident.

DISTRIBUTION AND HABITAT OF THE PLANT.

The wild rice plant (*Zizania aquatica* L.) occurs naturally over a wide area in the United States and southern Canada. The same species is also reported from Japan, Formosa, and China. It finds its best environment in the United States in fresh-water lakes and river sloughs and along the seacoast where streams meet tidewater. It requires that the water in which it grows be fresh, that is, not brackish, and that it be neither quite stagnant nor too swiftly moving, and while it thrives on a wide variety of soils under these waters it does best where the bottoms are soft and muddy.

The change in water level where the plant grows is an important item. For instance, it will frequently fail to do well or to grow at all in some of the northern lakes through which the Mississippi flows, especially if the annual change in water level in these lakes is more than 2 or 3 feet. There is on this account in the minds of some observers an opinion that wild rice normally grows only alternate years, or at least that it does not grow every year in a given locality. This idea is without foundation and its existence is probably due to the fact that occasional years of high water prevent the development of wild rice for that year, while a normal level the following year permits the regular growth.

This calls attention to the peculiar vitality of the seed of this plant. It is evident that if the growth of wild rice in a given locality is wholly prevented for a year by high water and there is an abundant growth the next year when the water level is normal, there must be a large proportion of the seed which remains dormant and viable for at least eighteen months after it reaches maturity.

In streams affected by tidewater, however, where the daily change of water level sometimes amounts to 3 feet or more, wild rice may grow vigorously. It is abundant along the shores of the lower Potomac, where it grows on mud flats that are nearly or quite exposed at low tide and submerged by 2 to 3 feet of water at high tide. The plant has in this case become adapted to this frequent change of water level, but if for any reason high water were retained over these beds for any considerable length of time during the early spring the plants would hardly develop.

The following table shows the results of analyses of soils from various wild-rice fields. These results are given to show the general nature and physical condition of the soils of lake bottoms where wild rice ordinarily grows and to show the limits of the adaptation of the plant to the salty conditions found where fresh-water streams meet tidewater. These analyses were made by the Bureau of Soils of this Department.

Analyses of soil samples taken from the wild-rice beds near Bemidji, Minn.

Sample number.	Per cent passing 2-mm. sieve.	Per cent organic matter.	Per cent CO_2.	Per cent nitrogen.	Resistance of saturated soil.[a]
1	85.3	0.63	0.08	0.04	4,700
2	95.7	9.05	18.00	.20	1,208
3	98.9	10.89	26.17	.65	1,114

Analyses of soil samples from wild-rice beds on Potomac flats.

Sample number.	Per cent passing 2-mm. sieve.	Per cent organic matter.	Per cent CO_2.	Per cent nitrogen.	Resistance of saturated soil.[a]
4	87.7	6.00	0.20	0.14	805
5	98.3	3.61	.24	.18	1,141

Analyses of soil samples from wild-rice beds at Chesapeake Beach, Md.

Sample number.	Per cent passing 2-mm. sieve.	Per cent organic matter.	Per cent CO_2.	Per cent nitrogen.	Resistance of saturated soil.[a]
6	95.7	1.56	0.16	0.07	333
7	98.9	1.30	.23	.06	45
8	90.9	1.86	.66	.06	42

[a] This heading refers to the electrical resistance of the saturated soil. In a general way, the electrical resistance of a saturated soil varies inversely with the content of soluble salts. See Bulletin No. 8, Division of Soils, U. S. Department of Agriculture, "An Electric Method of Determining the Soluble Salt Content of Soils," by Milton Whitney and Thomas H. Means; also see "Chemical Examination of Alkali Soils," by Atherton Seidell, page 65 et seq., in Bulletin No. 18, Division of Soils, U. S. Department of Agriculture, "Solution Studies of Salts Occurring in Alkali Soils," by Frank K. Cameron, Lyman J. Briggs, and Atherton Seidell.

Water soluble constituents in soil samples from Chesapeake Beach, Md.

Sample number.	CO_3.	HCO_3.	Cl.	SO_4.	Ca.	Mg.	Na.	K.	Total.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
6	0.034	0.048	0.042	0.016	0.018	0.006	0.044	0.016	0.224
7	Trace.	.108	.380	.018	.084	.018	.174	.030	.812
8	Trace.	.120	.408	.062	.032	.022	.250	.032	.926

Sample No. 1 was taken from near Bemidji, Minn. The lake bottom at this point bore practically no vegetation except the wild rice plants. The soil was hard and sandy and covered with a thin layer of pine bark and débris. While the plants were not numerous, they were vigorous and apparently doing very well.

Sample No. 2 was also taken near Bemidji, Minn., from the midst of a wild rice field where the water was 21 inches deep and the soil was hard and sticky below a thin layer of soft mud. This layer of soft mud, which the sample represents, was about 4 inches thick at

this point. Here the wild rice was not vigorous and the plants were branched very little, though they grew very thickly and stood 3½ to 4 feet above the water.

Sample No. 3 was also taken near Bemidji, Minn., from a locality where the wild rice was very thick and the plants were strong and vigorous and reached 6 feet out of water. The water was 21 inches deep and the bottom very soft for an additional 18 inches, and it was not firm for some distance farther down.

Sample No. 4 was taken from a wild-rice bed on the Potomac Flats, Washington, D. C. The water level here changes with the tide and varies from 6 inches below the level of the mud flat to 2½ feet above. The mud layer is 6 inches deep, underlaid with sand and gravel. The sample was taken from the 6-inch mud layer. The plants averaged about 7 feet in height and were vigorous and healthy.

Sample No. 5 was taken from another wild-rice bed on the Potomac Flats, Washington, D. C. The water level changes were as in No. 4, but the mud bank was higher, so that the water was only 14 inches deep at high tide. The mud layer had been made from dredging deposits and was 2 feet or more in depth. The plants were about 7 feet high, but somewhat less vigorous than those from the locality where sample No. 4 was obtained.

Samples Nos. 6, 7, and 8 were obtained from a wild-rice bed near Chesapeake Beach, on Chesapeake Bay. These samples were taken to determine the tidewater limits of wild rice or the amount of sea salt the plant can endure.

Sample No. 6 was taken where wild rice was growing thickly. The plants were vigorous, though rather small, not over 6 feet high and entirely out of water, but the soil was very wet and kept so by fresh-water seepage from a stream above.

Sample No. 7 was taken from near the same place as No. 6, but just outside the limits of the thick growth of wild rice, at a point where a single plant was growing feebly. This probably marks the extreme limit of adaptation of the plant to salty soils.

Sample No. 8 was obtained a few feet nearer the bay than Nos. 6 and 7 and where no wild rice was growing, but where the soil was supporting other vegetation.

Thus while it appears that wild rice will grow on a wide variety of soils, it needs for its best development approximately the following conditions:

Soft alluvial soil, covered with from 12 inches to 4 feet of water. The water level should not have an annual variation greater than 18 or 20 inches. The water should be constantly freshened by slight movement and consequent aeration.

LIFE HISTORY AND NATURAL PROPAGATION.

The wild-rice plant is an annual. It bears abundant crops of seeds which fall directly into the water as soon as ripe and lie buried in the mud below until the following spring when, if conditions are favorable, they germinate and produce new plants. In the northern lakes the long ribbon-like leaves appear floating upon the surface of the water late in May. By the latter part of June the stems have grown sufficiently to raise the leaves above the water. In the South the growth starts much earlier. On the mud flats of the lower Potomac the plants may be 6 inches high by the 1st of May. Strange as it may seem, the period of flowering and ripening of wild rice is almost the same in northern Minnesota and along the Potomac River near Washington, though on account of the earlier start in the southern region the period of growth is much longer.

The panicles appear during the latter part of July, and the flowers open immediately. The glumes of the pistillate flowers separate at the base to allow the stigmas to protrude and be pollinated and closing again soon after fertilization is accomplished leave the withered stigmas outside. Immediately after fertilization the young seed begins to elongate, and gradually fills the space within the floral envelope. This development requires about two or three weeks, and as soon as it is completed the connection with the stem is weakened and the seed falls off. The time of maturing of the different seeds in a single panicle extends over several days, the seeds on the tips of the branches ripening first.

The seeds on falling usually strike the water with the point of attachment below and sink immediately to the bottom. If by accident the distal end strikes first, enough small particles of air are caught by the barbs borne there to keep the seed on the surface of the water for a time, but as these air bubbles escape the seed sinks.

BOTANICAL DESCRIPTION.

Zizania aquatica L. is an aquatic, annual, monœcious grass. The stems are tall, erect, and hollow. The leaves are long and flat, with a heavy midrib, usually slightly nearer one margin of the blade than the other.

The flower cluster is a large panicle, bearing the staminate flowers on spreading branches below and the pistillate flowers on erect and more or less closely appressed branches above. The floral bracts are two in number, the outer five and the inner three nerved. The staminate flowers have six stamens. The pistillate flowers are borne with the larger glume toward the axis of the plant. The styles are nearly separate and stand at right angles to the floral axis, protruding on either side of the outer glume during and after fertilization.

The seed is nearly cylindrical in shape and long and slender, purplish black in color when mature, with a shallow crease along one side and a long, slender embryo.

GENERAL MORPHOLOGY.

For convenience in discussion we may consider the wild-rice plant as consisting of four principal areas: The Root, the Stem, the Leaf, and the Panicle.

The Root.—Unlike many grasses, wild rice produces upon germination but one root, arising from the embryo within the seed. The other two, which would make up the three commonly appearing from the seed of the grasses at germination, appear upon the first node of the shoot above the seed, which usually becomes the base of the stem, and from this and the nodes closely adjacent above arise the roots which maintain the life of the plant. In some cases large roots start from the first and even from the second node above the base of the stem in case a branch develops at either of these places and conditions are favorable, but for the most part the roots occur only at the base.

The base of the stem, shown in Plate II, fig. 2, is of peculiar curved shape. The roots arise in rows or whorls. The lower ones are slender and fibrous, while the upper ones, which are later and larger, function chiefly as a means of support or anchorage. The root system of the plant does not usually penetrate deep into the mud.

The Stem.—The stem of the wild-rice plant is essentially a hollow cone divided by four or five transverse walls at the principal nodes, which are the starting points of the leaves. Further divisions are made by transverse diaphragms which are called the pseudonodes. (Pl. II, fig. 1.) These pseudonodes occur at short intervals in each internode. It is probable that they function in making water-tight compartments to keep the plant afloat in case of injury to any portion of the stem, since the plant under normal conditions is held down by its roots rather than supported by them, and when released from its attachment to the soil readily floats to the surface of the water. These pseudonodes are probably the phylogenetic remnant of the pith of the stem, which has been preserved in this form as useful to the plant.

Branching of the stem is not uncommon, particularly when the plant is isolated or growing in shallow water. This branching usually occurs from the basal node or from the first node above, though rarely, if ever, does a branch which will mature arise from a node above the water. Vigorous branches arising from a basal node frequently throw out other branches, so that a cluster of several stems may arise from a single seed. In deep water, however, or where plants grow thickly there is little or no branching, even from the basal node.

The Leaves.—A leaf arises from each node of the stem and consists of the sheath, the ligule, and the blade.

The sheath clasps the stem closely and its edges overlap, completely covering the stem from the node from which it starts almost to the node above. The midrib is prominent in the sheath, as is shown in the sectional view in Plate II, fig. 1. The edges of the sheath are often streaked with purple, which color may also extend into the ligule or even into the blade of the leaf, being usually more pronounced near the margins of the part in which it occurs.

The ligule of the leaf is the thin, membranaceous extension of the sheath at the base of the blade, which clasps the stem above the sheath. (Pl. II, fig. 1.)

The blade of the leaf is peculiar chiefly in that its midrib is not in the center, being a little nearer one margin than the other. Those leaves which arise from the basal node or from the first node above the base are the ones which appear upon the surface of the water before the stem is developed. After the stem appears these floating leaves cease to function and wither away. The upper leaves, which are supported by the stem, do all the elaborating work after the stem appears and remain green and vigorous until after the seeds of the plant are mature.

The Panicle.—The panicle may be considered as having two areas—the staminate, which occurs below, and the pistillate, which occurs above. The staminate portion of the panicle consists of whorls of spreading branches arising from the joints of the axis. These primary branches bear numerous secondary branches, which in turn bear the flowers or spikelets.

The staminate spikelet consists of two unequal, soft, purple or pale green glumes inclosing six bright yellow stamens. The larger glume has five nerves and the other three. The larger glume bears a short, soft beak, and its edges overlap those of the smaller glume in the unopened spikelet. The stamens, after the spreading of the glumes, break open along their entire length and shed their bright yellow pollen out into the air, when it is carried by the wind to the stigmas of adjacent plants.

Cross fertilization of wild rice is insured because the pistillate portion of the panicle appears first from the leaf sheath and the stigmas have appeared and been pollinated by other plants before the staminate spikelets of the same plant have been released and opened.

The pistillate portion of the panicle is in the method of branching similar to the staminate portion, except that the branches are usually borne nearly or quite erect, in some cases being closely appressed to the main axis. The amount of spreading of the branches of the pistillate portion of the panicle is one of the important distinguishing marks between the varieties of wild rice. The spreading is due to the

development of the prophyllum at the juncture of the branches with the main axis. When this prophyllum is well developed the branch is forced out and the panicle is spreading. When it is not developed the branch remains erect and closely appressed to the main axis. For the most part, the wild rice of the northern Minnesota lakes is of the type shown in Plate V, fig. 2, having the branches of the panicle closely appressed, though there are occasional panicles in which some of the branches spread. On the other hand, the wild rice growing in the vicinity of the District of Columbia has a very open or spreading panicle. (Pl. V, fig. 1.)

The pistillate flower has two glumes and a bifurcated, much-branched stigma, and two lodecules which surround and almost conceal the comparatively small ovary. (Pl. III, fig. 2.) The larger glume is five ribbed and bears at its summit a stiff, usually somewhat twisted awn of several times its own length, which bears numerous barbs or bristly hairs. There are also short bristles borne along the edge of the glume and a short distance down along each of its nerves. (Pl. IV, fig. 1.) All these barbs and bristles point toward the tip of the glume and are probably of assistance to the seed in burying itself in the mud. The smaller glume (Pl. III, fig. 2) is much more delicate than the larger one and is almost entirely inclosed by it. It has three delicate nerves and its tip is so surrounded by that of the larger glume that it is only with difficulty that they can be separated. When the seed reaches maturity and fills the glumes they are held so firmly together that they must be broken to be removed.

The bifurcated style and two lodecules are shown in Plate III, fig. 2. The styles are so bent as to stand at right angles to the axis of the ovary. The behavior of the lodecules at the time of fertilization is very interesting. By expanding, as the result of the absorption of moisture, they force the glumes apart at the base (Pl. IV, fig. 1), and at the same time the stigmas appear on either side of the smaller glume, where they are in position to catch any pollen that may be blown upon the plant. As soon as fertilization is accomplished the stigmas wither and the lodecules cease their pressure, the smaller glume again returns within the margins of the larger one, and the ovary begins to develop.

VARIETIES.

While distinct differences in size and form of panicle, the coloration of the plant, and the size of the seed have been noticed in wild rice from various regions, there is as yet insufficient evidence to justify making a new species. It is impossible to say at the present time to what extent these differences are due only to environment. The wild rice of northern Minnesota and that growing along the lower Potomac show the extreme variations in some respects. The Potomac plants

grow 8 to 10 feet high and 6 to 7 feet above the water and have a very large panicle, often exceeding 2 feet from the lower joint to the tip of the pistillate end. The pistillate portion of the panicle in the Potomac plant is distinctly spreading and the branches often bear 17 to 27 seeds. The plant common to the northern Minnesota lakes is smaller than that of the Potomac, usually reaching only 3 or 4 feet above the water. The panicle is shorter, rarely if ever exceeding 20 inches in length, more often 16 inches or less. The pistillate portion rarely exceeds 10 inches in length and usually has its branches closely appressed. When spreading of the branches of the pistillate portion of the panicle does occur in the wild rice of the northern lakes it is seldom that all the branches of a panicle are spreading—frequently only 1 or 2 of them, rarely more than 4 or 5—and the branches of the panicle of the Minnesota plant rarely carry more than 9 seeds, usually from 3 to 7.

The following table of seed measurements is given to show the difference in size of wild rice seeds from different regions. These measurements were made on the seed after the hull was removed and are given in metric millimeters.

Wild rice seed from—	Number measured.	Length.			Diameter.		
		Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Potomac River	100	13.77	18.00	8.90	1.04	1.30	0.80
Port Hope, Ontario	50	19.29	23.30	14.20	1.67	2.00	1.40
Minnesota	50	12.00	15.10	9.00	1.65	2.28	1.30

It will be observed from this table that the seeds from northern varieties are larger, particularly much thicker, than those of the Potomac variety.

There is also in the northern-grown wild rice a marked distinction in coloration. Some of the plants are a rich purple color in the panicle and have a large amount of purple coloring in the leaf sheath and along the margin of the leaf blade, while others remain with almost no suggestion of any color but green, except perhaps a pinkish tinge in the glumes of the staminate flowers. The stamens in all cases are uniformly of a rich bright yellow, and the mature seeds are always black. Some seeds are green or greenish brown in color, but this is due to their immaturity. It is difficult to understand this difference in color in wild-rice plants. It has been shown that the plants are uniformly cross-pollinated, and plants of both colors grow side by side in the northern lakes, though in some localities plants of one color or the other predominate; and while one may find a few cases of colors intergrading between these two, the extremes of coloration are the rule, and, except in rare cases, marked coloration, when it occurs, extends throughout the plant. For instance, a dark purple pistillate

panicle almost invariably accompanies dark purple staminate flowers and a large amount of that color in the leaf sheath and blade. Color variation is found in the Potomac wild rice, though to a much less degree.

DISEASES.

So far as has been observed, but one fungous disease seriously affects wild rice. This is a form of ergot (*Claviceps*, species undetermined, Pl. IV, fig. 2). This disease has been found widely distributed through the wild-rice fields of northern Minnesota, and though it is seldom abundant, no field was found in which close observation did not reveal its presence. If it occurs in large quantities in any place it is, of course, a decided disadvantage, as the seed is not usually so treated as to make the separation of the sclerotia at all easy, and serious damage might result from the use for food of badly infected seed on account of the poisonous properties of the fungus.

HARVESTING THE SEED.

Almost all the wild-rice seed now harvested is gathered by Indians into birch-bark canoes. This is done usually by two persons working together, one standing in the bow of the canoe and propelling it with a forked stick and the other seated in the stern with two short sticks, by means of which the plants on either side of the canoe are gently pulled over it and the ripe seed beaten off. No attempt is made to get all the seed off the plants at one time. It is customary rather to take only the seed which falls readily and to visit the same plants later as more seeds ripen. The period of ripening extends over nearly two weeks for any field and over several days for any single plant, so that were one to attempt to harvest all the rice on a given area it would be necessary to go over that area at least four or five times at intervals of from two to three days. Recently some attempts have been made to construct machinery for harvesting wild rice seed from boats driven by screw or drawn by cable. So far, however, such endeavors have not been entirely successful.

It is customary in some sections for the Indians to prepare wild rice for harvesting by going through the field before any of the seed is quite ripe to draw the heads of adjacent plants into bunches, which are firmly tied together, so that the seed, as it ripens, will not fall. This custom, however, is not universal, and is only resorted to when the supply of wild rice is not abundant and it is desirable to gather as much as possible from certain fields. When a portion of a field is so tied up it can be left until after all the untied seed has been harvested or has fallen, and in this way the harvesting period is extended. This preliminary tying is, of course, a tedious operation, and would be expensive were the time of the operator a salable quantity. The

harvesting of wild rice is not regarded by the Indians as a particularly arduous task, though attempts by white men to do the same work have not proved very successful.

PREPARATION OF THE SEED FOR FOOD PURPOSES.

After the wild-rice seed is harvested into the canoe, it is taken ashore and put in piles or spread out for a preliminary drying. (Pl. VI, fig. 2.) If allowed to remain piled up for more than a few hours when fresh, fermentation sets in, as the seed is very damp and soft when gathered, so that almost immediately after it is harvested it is either spread out thinly to dry, or is parched ready for hulling. The parching is at present done by the Indians in a very primitive way, as is shown in Plate VI, fig. 1. The seed is put into a kettle over a slow fire and stirred with a stick until it is roasted so that the hull is brittle enough to be easily broken. Not much more than a half bushel can be parched at a time, and it requires from half an hour to an hour to parch a single lot, and the seed demands constant attention throughout the parching process to keep it from burning. Unless stirred evenly the kernels pop open or become so brittle as to break up badly in the subsequent hulling process. There is a most excellent opportunity for the development of some simple device for the uniform parching of wild-rice seed. The parching is what gives the seed its highly esteemed flavor as a food, and if this operation and the subsequent hulling can be done uniformly the percentage of burned and broken seed will be much less than at present, and, furthermore, the cost of production of the food will be very greatly reduced.

After the seed has been parched it is spread out to cool, and soon after it is hulled. The hulling is at present the most tedious operation in the whole process of preparation. The Indians ordinarily accomplish it by putting about a bushel of the seed into a hole in the ground, lined with cedar staves or burnt clay, and then beating or punching it with heavy sticks. Often three or four men work together on one lot. After the seed has been beaten until the hulls have all been cracked or broken, the grains and hulls are separated by tossing the mixture up into the wind from light birch-bark baskets. After the parching and hulling are finished the grain is sufficiently dry to keep indefinitely. Plate VII shows some wild-rice seed with the hull on, some with the hull removed, and some parched seed, also with the hull removed.

As a food material this parched wild rice is highly esteemed by those who like the "gamy" flavor which it acquires by parching. It is cooked with wild fowl and also used as a breakfast food. For either purpose it should have several preliminary washings in cold water to remove any disagreeable smoky taste. It is also used to a limited extent for making rice cakes. For this purpose it is milled

and the darker outer coat is sifted out. When milled without being parched this outer coat is difficult to remove, as it breaks up into small particles that do not readily separate from the flour, so that for all use as food the seed should be first parched and hulled.

The results of chemical analyses given below show approximately the comparative value of wild rice for food purposes. For the table and the statement concerning it the writers are indebted to Dr. C. F. Langworthy, of the Office of Experiment Stations of the Department of Agriculture.

THE FOOD VALUE OF WILD RICE.

The table below shows the chemical composition of wild rice and a number of common cereal grains. Wild rice is usually cooked in a whole or cracked form; therefore the articles selected for purposes of comparison are the whole grains and breakfast foods rather than the ground grains.

Comparison of wild rice and other grains.

	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
Wild rice:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Whole grain	9.5	12.9	1	75.2	1.4	1,625
Ground	13	10.9	.8	74	1.3	1,740
Parched whole grain	11.2	14.6	.7	72.3	1.2	1,620
Parched and ground	9.5	11.5	.8	76.9	1.3	1,800
Rice, polished	12.3	8	.3	79	.4	1,630
Barley, pearled	11.5	8.5	1.1	77.8	1.1	1,650
Wheat, cracked and crushed	10.1	11.1	1.7	75.5	1.6	1,685
Oats, rolled	7.7	16.7	7.3	66.2	2.1	1,850
Corn meal, unbolted	11.6	8.4	4.7	74	1.3	1,730
Hominy	11.8	8.3	.6	79	.3	1,650
Kafir corn	16.8	6.6	3.8	70.6	2.2	1,595
Buckwheat flour	13.6	6.4	1.2	77.9	.9	1,620

As will be seen, wild rice resembles common cereal grains quite closely in composition. As is the case with wheat, rye, barley, and other grains, the greater portion of the nutritive material consists of carbohydrates, although the amount of protein is proportionately large. Wild rice contains little fat, in this respect resembling rice, barley, and wheat more closely than corn and oats. Judged by its composition and fuel value, it compares very favorably with the common cereal grains. Too much importance should not be placed on the variation in constituents as shown by figures like the above, since it must be remembered that a given constituent in any of the grains may vary to rather wide limits. For instance, the protein in common white rice varies from about 6 to 11 per cent. So few analyses of wild rice are available that but little can be said regarding the range in the

proportional amount of the different constituents. Furthermore, little is known of the comparative digestibility of wild rice and other grains. From its extended use by the Indians and others it seems safe to assume that this grain is wholesome, and as said above, analysis shows that it is, like the more common cereals, a nutritious food. So far as can be learned no extended study of the proteids, fats, and carbohydrates of wild rice has been carried on. Some tests which were recently made showed that starch is present in large amounts and in the form which gives a blue color with iodin. No attempt was made to study other members of the carbohydrate group, if such were present. Indications were observed of an enzyme which caused fermentation of the grain when moistened.

When wild rice is soaked in water a peculiar odor is noticeable, recalling that of damp hay. When it is boiled it also possesses a characteristic odor, something like that of boiled barley. The raw grain has a starchy taste, while the cooked grain resembles barley much more than white rice in taste. The flavor is characteristic and is relished by many. When cooked, the wild-rice kernels expand to about two or three times their original size, and except for the bits of dark outer covering ordinarily present the cooked material is of a grayish-white color. In Minnesota and adjacent States where wild rice is best known it is usually eaten as a breakfast cereal, or cooked in much the same manner as ordinary white rice.

ARTIFICIAL PROPAGATION.

When wild-rice seed is to be used for propagating purposes it is now customary to secure it from Indians as soon as possible after it is harvested, and to spread it out thinly over some sort of a floor in the shade and stir it frequently until it is dry. Since it has been extremely difficult to germinate seed so treated, or to secure successful plantings from seed obtained upon the market, there is good reason for believing that it is the present methods of curing seed that are at fault. It was largely for the purpose of determining where this fault lay and how best to remedy it that investigations were instituted. It is true that many of the unsuccessful plantings made during the past owe their failure to the improper selection of the place for planting, due to ignorance regarding the nature of the plant and its environmental requirements; but it is certainly true that the plant may grow in many localities where it is not now found, provided good seed is obtainable.

PREVIOUS FAILURES IN PLANTING.

Some instances are reported where successful plantings have been made, but the greater number have proved entire failures. This is no doubt due to the fact that the seed which is ordinarily obtained from the Indians is treated in such a manner as to kill the germ.

It is allowed to ferment during the curing process or to become too dry, either of which conditions seriously injures its vitality. Practically all attempts to germinate thoroughly dried seed have proved unsuccessful.

PLANTINGS MADE IN 1902.

In order to determine the best methods to be used in curing, storing, and planting the seed a series of plantings was made both in northern Minnesota and at Washington, D. C. The seed was collected fresh and planted in tubs of mud sunk into the muddy bottoms where wild rice naturally grows. The tubs were covered with fine screens to prevent other seeds getting in and to prevent the removal or destruction of the seed planted. These plantings were examined from time to time. No signs of germination were noticed in the autumn immediately following the planting, but at the time the naturally sown seed around the tubs began to grow, in the spring of 1903, the seed in the tubs was found to be germinating freely, thus showing that when the seed is planted in a fresh condition and never allowed to heat or dry it will grow well.

Plantings were also made by Mr. D. W. Hallam, of Dover, N. H., in a number of ponds where wild rice had never grown. In some the seed was planted in the fall of 1902, and in others in the spring of 1903. These ponds were visited the second week in June, 1903, and the plants were found to be growing well in all cases.

STORING SEED.

Mr. Hallam has succeeded in keeping wild rice seed over winter with its vitality uninjured. The following extract from a letter from him under date of April 15, 1903, shows how this was done:

> The wild rice was ordered with instructions to ship as soon as gathered without drying. I received it on the 27th day of October, 1902. The barrel was placed on end in the shade out-of-doors, the head taken out, with about a bushel of seed, and a faucet was put in at the bottom to drain the water. The seed was weighted with a cover, and cold water enough to fill the barrel put in each morning and drained out daily. The barrel was kept full. On the 5th of December ice began to form on the inside of the barrel. Care was taken in adding water so as not to burst the barrel. By the 25th of December there was a frozen mass of ice and seed that filled the barrel. No water was then added until the middle of March, and then only enough to keep the barrel full, for as yet there was quite a mass of ice and seed. Since April began it has been necessary to change the water daily. Our water here is quite cold, 45° to 55° F. I have sent a sample bottle.

The seed received from Mr. Hallam with this letter had germinated and had sprouts from one-half to 1 inch in length when it arrived. Later, a larger quantity of seed, about 2 quarts, was received from Mr. Hallam, of which 75 per cent had germinated.

It seems from the results of the experiments referred to that wild rice can be successfully grown from seed either by sowing the fresh

seed as soon as it is gathered or by keeping it in water over the winter and sowing in the spring. In most instances it will no doubt be found more satisfactory to sow in the fall, providing the place sown can be protected from waterfowl and other animals likely to destroy the seed, since such a practice will avoid the trouble of keeping the seed wet during the winter. When the seed is kept in water, either for storage or transportation, the water must be changed frequently or aerated, as fermentation sets in if it is allowed to stand for any length of time.

The seed can be shipped or stored for a short time by packing it in dampened moss or excelsior, and this is a convenient way to prepare it for shipment. It is necessary to separate the seed from the moss or excelsior by layers of cloth, as it can not conveniently be sown when mixed with either. The package, when made up thus for shipment, must not be too thick or too tight to prevent some slight circulation of air, or fermentation will at once set in.

SUGGESTIONS FOR HARVESTING, STORING, AND PLANTING.

(1) Orders should be placed before the harvesting season is commenced, so that the seed may be shipped immediately after it is gathered.

(2) Care should be taken to gather only fully matured seed.

(3) Seed should not be allowed to dry when it is to be used for propagation. For shipment or storage it must be kept wet, with frequent changes of water, or packed in damp moss or excelsior in ventilated packages.

(4) Wherever practicable, autumn planting is recommended.

(5) Care should be used in selecting the place for planting seed to get the proper depth of water—from 1 to 3 feet, with a thick layer of soft mud underneath—and the water should be neither quite stagnant nor too swiftly moving.

DESCRIPTION OF PLATES.

PLATE I. Frontispiece. Field of wild rice just heading out, near Bemidji, Minn. This field is representative of a large area in northern Minnesota and Wisconsin, where the shallow lakes are practically filled with wild-rice plants. This photograph was taken August 28, 1902.

PLATE II. Stems of wild rice. Natural size. Fig. 1.—Portion of the stem of a young plant illustrated in long section to show the pseudonodes and a portion of the leaf-sheath, together with a portion of the stem surrounded by the leaf-sheath, and showing also the ligule and a portion of the leaf-blade with prominent midrib. Fig. 2.—An old stem of wild rice showing the curvature of the base and the root scars in whorls.

PLATE III. Fig. 1.—A staminate flower of wild rice shown in its natural position, with the glumes spread apart and the six empty anthers still retained by the filament. Enlarged seven times. Fig. 2.—Pistillate flower of wild rice, with the outer glume removed to show the lodecules and the stigmas in their natural position, projected on either side of the inner glume. Enlarged seven times.

PLATE IV. Fig. 1.—Pistillate flower of wild rice, showing both the outer and inner glumes below and only the outer glume, with its prominent awn and bristly hairs, above. The illustration shows the flower at the time it is ready for fertilization. The lodecules have expanded and forced the glumes apart below to allow the stigmas to protrude to catch the pollen blown from other plants. Enlarged seven times. Fig. 2.—Panicles of wild rice showing ergot infection. The fungous disease (*Claviceps*, species undetermined) attacks the young ovaries of the wild-rice plant and completely destroys them, producing in their stead irregular, purplish black masses of compact hyphæ which are called sclerotia. Natural size.

PLATE V. Panicles of wild rice. Fig. 1.—Type of the panicle of Potomac wild rice. In this type the branches of the pistillate portion of the panicle are spreading and bear from 17 to 27 spikelets or seeds. About one-fifth natural size. Fig. 2.—Type of the panicle of Minnesota wild rice. In this type the branches of the pistillate portion of the panicle are closely appressed to the main axis and bear from 3 to 7 spikelets or seeds. About one-fourth natural size.

PLATE VI. Fig. 1.—Indian woman parching wild rice. The wild rice is parched in a large kettle over a slow fire and must be stirred continually during the operation to prevent scorching and popping. The birch-bark basket shown in the foreground is the one used for separating the wild-rice seed from the hulls after it has been parched and sufficiently pounded. Fig. 2.—Freshly gathered wild rice drying on a scaffold. The seed in this condition is exceedingly moist and will ferment unless constantly stirred and allowed to dry rapidly.

PLATE VII. Wild-rice seed with the hull on (C), with the hull off (B), and parched (A); the last also with the hull removed. The parched seed shown in the upper portion of the picture is in condition to be used for food. Natural size.

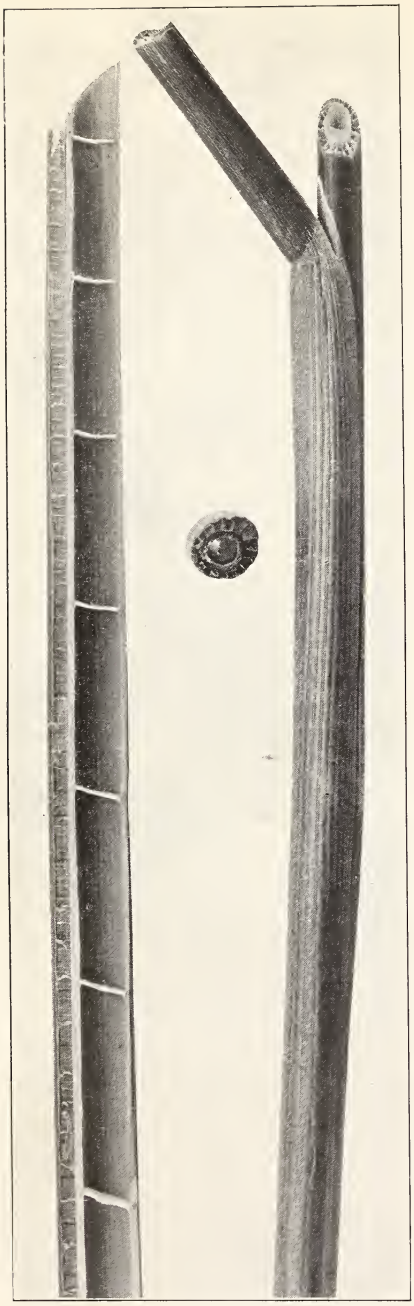

FIG. 1.—YOUNG STEMS OF WILD RICE, SHOWING PSEUDONODES. (NATURAL SIZE.)

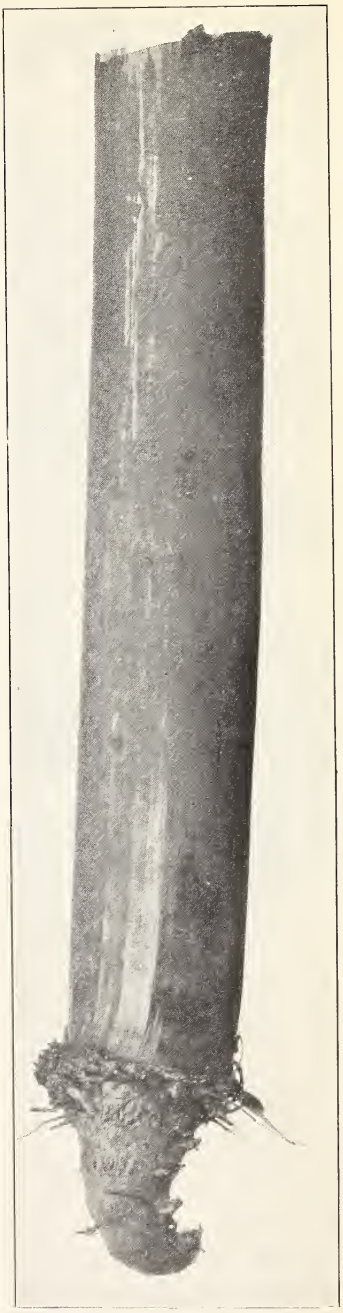

FIG. 2.—AN OLD STEM OF WILD RICE, SHOWING THE CURVATURE OF THE BASE. (NATURAL SIZE.)

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FIG. 1.—A STAMINATE FLOWER OF WILD RICE. (ENLARGED SEVEN TIMES.)

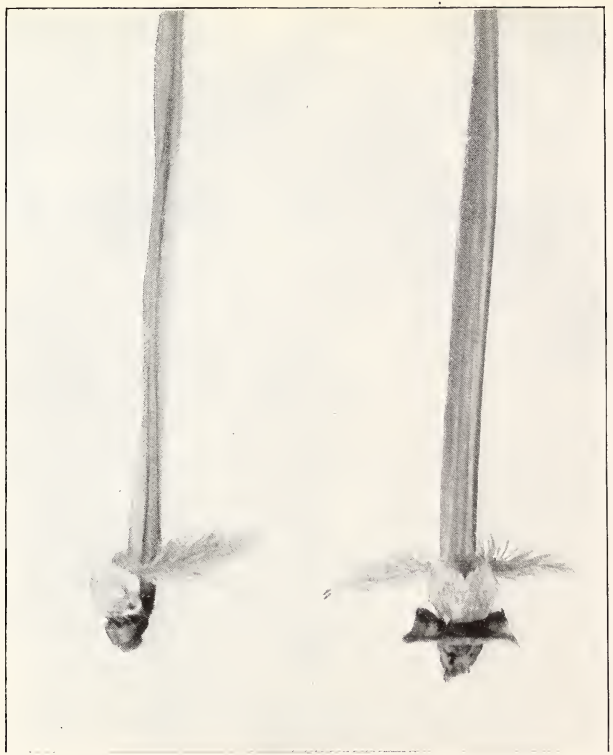

FIG. 2.—A PISTILLATE FLOWER OF WILD RICE, WITH OUTER GLUME REMOVED. (ENLARGED SEVEN TIMES.)

FIG. 1.—A PISTILLATE FLOWER OF WILD RICE. (ENLARGED SEVEN TIMES.)

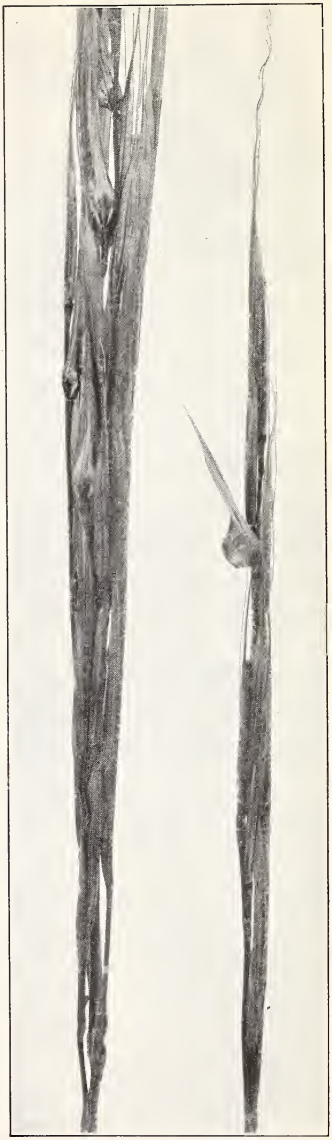

FIG. 2.—PANICLES OF WILD RICE, SHOWING ERGOT INFECTION. (NATURAL SIZE.)

FIG. 1.—TYPE OF THE PANICLE OF POTOMAC WILD RICE.

FIG. 2.—TYPE OF THE PANICLE OF MINNESOTA WILD RICE.

FIG. 1.—INDIAN WOMAN PARCHING WILD RICE.

FIG. 2.—FRESHLY GATHERED WILD RICE DRYING ON A SCAFFOLD.

WILD RICE SEED WITH THE HULL ON (*C*), WITH THE HULL OFF (*B*), AND PARCHED (*A*). (NATURAL SIZE.)